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DRY MATTER AND POD YIELD OF FRENCH BEAN VARIETIES AS INFLUENCED BY VARIOUS NITROGEN APPLICATION

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Abstract

Nitrogen (N) requirement of French bean (*Phaseolus vulgaris* L.) in Bangladesh is not yet determined. The present study has evaluated the performance of French bean varieties and nitrogen rates through a field experiment conducted at the research field of Plant Physiology Section of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) during *rabi* seasons of 2016-17 and 2017-18). The experiment was set up with frenchbean varieties BARI Jharshim-1 and BARI Jharshim-2 and N rates viz., 0, 75, 100, 125 and 150 kg N/ha arranged in a randomized complete block design, with three replications. The variety BARI Jharshim-1 treated with 150 kg N/ha produced the highest in respect of shoot dry matter yield (879.65 g/m^2), number of pods/plant (29.70), weight of pods/plant (147.20 g) and green pod (marketable) yield of 19.48 t/ha); in contrast, lower yield and yield attribute was obtained with BARI Jharshim-2 with 125 kg N/ha. Pods of both varieties showed appreciable amounts of protein, vitamin-C and vitamin-A when N was fertilized at 125 followed by 150 kg/ha.

Keywords: French bean, dry matter, pod yield, quality, nitrogen, pod protein.

Introduction

Bush bean or Bushy type French bean (*Phaseolus vulgaris* L.; Family-*Leguminosae*) is an important short duration leguminous pod vegetable grown all over the world. It is generally grown in Bangladesh during *rabi* (winter) season for its tender green pods with high protein, calcium and iron contents

Among plant nutrients nitrogen has been considered as a major growth and development element. Unlike other legumes, Bush bean is inefficient in symbiotic nitrogen fixation (Ali and Lal, 1992) as it lacks nodulation due to the absence of NOD gene regulator (Kushwala, 1994) even with native *Rhizobia* and commercially produced cultures. In French bean, the calculated N fixation is about 10 kg N ha^{-1}, a small part of the total N uptake of 150 to 400 kg N ha^{-1} (Fageria *et al*., 2014). Hence, this crop requires a large amount of nitrogenous fertilizer for exploiting its yield potential (Ssali and Keya, 1986; Sharma *et al*., 1976). Its response to applied nitrogen is as high as 124 kg/ha (Rana *et al*., 1998) and even as high as 180 kg/ha (Siddiqui, 2010). Srinivas and Naik (1990) recorded the maximum pod yield of French bean at 160 kg N/ha that was identical with 120 kg N/ha. Ivanov *et al*. (1987) also obtained the highest pod

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yield of French bean with 150 kg N/ha. Abebe *et al.* (2019) reported that pod yield (17.09 t/ha) was found maximum from 150 kg N/ha.

Dry matter production and yield of a crop largely depend on the function of leaf area development and consequently photosynthetic activity. High photosynthetic rates generally are capable of producing high amount of biomass and nitrogen deficiency strongly reduces photosynthetic rate and leaf expansion, enhances leaf senescence, alters canopy morphology in crop plants and consequently reduces crop productivity (Evans and Terashima, 1987). Without vigorous early growth, functional leaf area (source) at the onset of flowering will be inadequate to produce assimilates needed during pod formation and seed development eventually reducing yield of the crop. This suggests that efforts should be made to increase leaf area prior to anthesis by agronomic manipulation i.e. proper tillage, spacing, fertilization etc. (Poehlman, 1991). Remobilization of nitrogen from photosynthesizing leaves can be stopped or reduced by supplemental nitrogen application. Nitrogen is critically deficient in most of the soils of Bangladesh (Hoque, 1983). Practically, the research work is limited about the effect of nitrogen in respect of dry biomass production, harvest index and pod yield of bush bean. Therefore, the present investigation was undertaken to determine the optimum nitrogen dose on yield of pods by influencing dry matter production of two varieties of bush bean.

Materials and Methods

The experiment was conducted at the Plant Physiology Research Field of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during winter (*rabi*) season of 2016-17 and 2017-18. The terrace soil of Gazipur is medium high land with clay loam texture and belongs to Chhaita Series under Modhupur Tract (AEZ-28). Prior to experimentation initial soil sample (0-15 cm depth) was collected from the field and the soil was analyzed for chemical properties in both years. The soil pH was 6.1 and 5.9, respectively for 2016-17 and 2017-18. The average total N was 0.06 %; available P, S, Zn and B were 10.4, 16, 0.92 and 0.30µg/g, respectively and available K was 0.17 meq/100 g soil.

The treatments comprising two varieties (BARI Jharshim-1 and BARI Jharshim - 2) and five levels of nitrogen (0, 75, 100, 125 and 150 kg/ha) were replicated thrice in a RCB factorial design. The size of each plot was 3.0 × 1.0 m. The plant spacing was 25 x 10 cm. Seeds were sown by hand on November 26, 2016 and November 20, 2017 at the rate of two seeds/hill. Before sowing seeds were treated with Bavistin @ 2.5 g/kg seed. After 15 days of sowing (DAS) thinning was done keeping one healthy seedling/hill. Two hand weedings were done at 15 and 50 DAS. A uniform dose of P (40 kg/ha), K (80 kg/ha), S (10 kg/ha), Zn (1.98 kg/ha), B (0.84 kg/ha), and cowdung (5 t/ha) was used in this experiment

(FRG, 2012; Sen *et al*., 2010). The full dose of phosphorous, potassium, sulphur, zinc, boron, cowdung, and one-third of nitrogen as per treatment was applied during final land preparation and the rest half of nitrogen was applied at 20 and 35 days after sowing. The nitrogen was top dressed between the rows in appropriate moist condition. The source of N, P, K, S, Zn, and B were urea, Triple Supper Phosphate, Muriate of Potash, gypsum, zinc sulphate (monohydrate) and boric acid (lab grade). In addition to pre-sowing irrigation, four additional irrigations were given to the crop. Tender green pods were picked out at regular intervals for recording plot wise yield and a total of five pickings were made in both the years. In the first year, the harvesting of pods of BARI Jharsheem-1 started from January 25, 2017 and continued up to February 19, 2017 whereas harvesting of pods of BARI Jharshim-2 started from February 02, 2018 and continued up to February 26, 2018. In 2nd year, pod harvest of BARI Jharshim-1 started from January 13, 2018 and continued up to February 04, 2018 whereas harvesting of pods of BARI Jharshim-2 started from January 20, 2018 and continued up to February 08, 2018. The plants of both varieties were kept in the field up to March 01, 2018 for recording data.

Five plants were sampled randomly in each treatments and averaged for recording dry weight in aerial parts (leaf, stem and pod), at 100 DAE (days after emergence). The samples were first sun dried and thereafter in oven at 72^{o}C till a constant weight was recorded. From these observations the component dry matter per plant was calculated. TDM (total dry matter) were determined. Pods were harvested at regular intervals from the five tagged plants and pod number and weight were calculated. From each harvest ten pods were randomly selected and weighed. Harvest index (HI) was calculated using the following formula:

$$\text{HI} = \frac{\text{Dry weight of pod (kg/m}^2\text{)}}{\text{Total dry weight (kg/m)}^2\text{)}} \times 100$$

ß-carotene was determined following acetone-hexane method as stated by Masayasu and Yamashita (1992). 100 grams of fresh pods of French bean varieties was dipped in acetone-hexane (4:6) solution for extraction of the pigment. Then the supernatant was collected in vials and the optical density of the supernatant at 663 nm, 645 nm, 505 nm and 453 nm were measured by spectrophotometer (UV-1800, Shimadju, Japan). From these values, the content of ß-carotene was estimated using the following formula: ß-carotene (mg/100g) = $0.216A_{663}$ $-1.22A_{645}$ $-0.304A_{505}$ + $0.452A_{453}$ (A_{663}, A_{645}, A_{505} and A_{453} are absorbance at 663 nm, 645 nm, 505 nm and 453 nm, respectively). Vitamin A (IU/100 g FW) was estimated from ß carotene (µg/100 g FW) by dividing 0.6.

Vitamin-C (ascorbic acid) in fresh pod was estimated by 2,6-Dichlorophenol-indophenol visual titration method as described by Rangana (1986). The reagents used for the estimation of vitamin-C were as follows: 1) Metaphosphoric acid

(6%), 2) standard ascorbic acid solution, 3) 2-6 dichlorophenol-indophenol dye. Twenty grams fresh pod was weighed accurately by an electrical balance and blended. The blended sample was then transferred to a 100 mi volumetric flask and the volume was made upto 100 ml. For estimation of vitamin-C, the following steps were followed: Standardization of dye solution, preparation of solution and then titration. The formula of estimating: Vitamin-C content (mg per 100 g of florets) = $(T\times D\times V_1\times 100)/(V_2 \times W)$; Where, T=Titre, D=Dye factor, V_1 = total volume of blended sample (100 ml), V_2 = Volume of extract taken for estimation (titration) (5 ml) and W = weight of sample taken for estimation (20 g) TSS (%) in fresh pod was estimated by a Hand Refractometer. At first a small amount of fresh pod was pressed to collect juice. This juice was then put on the prism of the refractometer and data was recorded.

Representative samples of pods were analyzed for total N content by using Kjeldals' method. Protein was estimated by multiplying the total Nitrogen (TN) by 6.25 (AOAC,1990).

The MSTAT-C computer package was used to analyze the data and mean separation was done by LSD test at 5% level of probability.

Results and Discussion

Shoot dry weight, pod dry weight, total above ground dry weight and harvest index

Maximum shoot dry weight was obtained from $V_1\times N_4$ combination (452.07 g/m^2) closely followed by $V_1\times N_3$ (446.59 g/m^2), $V_2\times N_4$ (441.50 g/m^2) and $V_2\times N_3$ (434.06 g/m^2) combinations (Table 1). The $V_1\times N_4$ combination gave the maximum pod dry weight (427.59 g/m^2) which was identical with $V_1\times N_3$ (422.98 g/m^2). The same trend was followed in case of total above ground dry weight as that of pod dry weight. In case of BARI Jharshim-1, maximum harvest index was recorded from 125 kg N/ha (48.64%) that was statistically similar with 150 kg N/ha (48.61%). Similar trend was also followed in case of BARI Jharshim-2 treated with 125 and 150 kg N/ha. Kakon *et al.* (2016) also reported the highest dry matter from 150 kg N ha^{-1} in a seed yield from variety BARI Jharsheem-1. Shubhashree *et al*. (2011) obtained the highest total dry matter $plant^{-1}$ (15.65 g) with the application of 120 kg N ha^{-1} in combination with 75 kg P_2O_5 (33 kg P) ha^{-1} and 60 kg K_2O (50 kg K) ha^{-1}. Kakon *et al.* (2016) reported an increased dry matter of 300-330 g m^{-2} (13.64 -15.0 g $plant^{-1}$) from 150 kg N ha^{-1} in a seed yield of BARI Jharsheem-1. Lad *et al*. (2014) obtained maximum plant dry weight, and pod dry weight /plant from N @ 150 kg/ha. Abebe *et al.* (2019) also reported that maximum shoot fresh weight (345.00 g m^{-2}), pod dry weight (391.87 g m^{-2}) and total above ground dry weight (737.07 g m^{-2}) of French bean were found maximum from 150 kg N/ha.

Table 1. Shoot dry weight, pod dry weight, total above ground dry weight and harvest index as influenced by varieties and nitrogen levels at harvest (pooled of 2016-17& 2017-18)

Treatment	Shoot (leaf + stem) dry weight (g/m^2)	Pod dry weight (g/m^2)	Total above ground dry weight (g/m^2)	Harvest index (HI) (%)
$V_1 \times N_0$	147.95	126.43	274.38	46.08
$V_1 \times N_1$	349.13	264.50	613.63	43.10
$V_1 \times N_2$	370.66	345.71	716.37	48.26
$V_1 \times N_3$	446.59	422.98	869.56	48.64
$V_1 \times N_4$	452.07	427.59	879.65	48.61
$V_2 \times N_0$	125.25	94.39	219.63	42.97
$V_2 \times N_1$	299.81	254.18	553.99	45.88
$V_2 \times N_2$	353.43	311.47	664.90	46.84
$V_2 \times N_3$	434.06	395.32	829.38	47.66
$V_2 \times N_4$	441.50	396.86	838.36	47.34
LSD (0.05)	34.21	22.53	41.16	0.37

V_1=BARI Jharshim-1, V_2 = BARI Jharshim-2; N_0 = 0 kg N/ha, N_1=75 kg/ha, N_2 = 100 kg/ha, N_3= 125 kg/ha and N_4 = 150 kg/ha.

Pod Yield and Yield attributes

Number of green pods/plant

In 2016-17, BARI Jharsheem-1 coupled with 150 kg N/ha gave the maximum number of pods (30.01 /plant), which was statistically similar to $V_2 \times N_4$ and $V_2 \times N_3$ combination (Table 2). In 2017-18, pods /plant was found maximum from $V_2 \times N_4$ (31.09 /plant) closely followed by $V_2 \times N_3$ (29.91/plant) and $V_1 \times N_4$ (29.40 /plant). In mean data, the combination $V_2 \times N_4$ gave maximum pod number (30.49/plant) followed by $V_1 \times N_4$ (29.70/plant), $V_2 \times N_3$ (29.38/plant) and $V_1 \times N_3$ (28.38 /plant). The lowest number of pods/plant was recorded from without N treatment interacted with both the varieties. Sen et al. (2010) obtained highest pod number (27.90 /plant) from 150 kg N/ha. Wondimu and Tana (2017) also obtained the highest number of pods (31.37 $plant^{-1}$) from the application of maximum nitrogen dose. Abebe *et al*. (2019) reported that maximum pod number/plant (41.33) was found from 150 kg N/ha.

Weight of green pods/plant

BARI Jharsheem-1 treated with 150 kg N/ha produced the maximum weight of green pods/plant (148.50 g in 2016-17, 145.90 g in 2017-18 and 147.20 g in mean data) followed by the same variety treated with 125 kg N/ha (147.10, 144.60 and 145.90 g/plant in 2016-17, 2017-18 and mean data, respectively) (Table 2). In case of BARI Jharsheem-2, application of N @ 150 kg/ha gave the maximum weight of green pods (140.00, 139.50 and 139.70 g/plant in 2016-17, 2017-18 and mean data, respectively) that was identical with 125 kg N/ha (139.30, 138.90 and 139.10 g/plant).

Green pod yield

In 2016-17, BARI Jharshim-1 treated with 150 kg N/ha gave the maximum green pod yield (19.53 t/ha) which was statistically similar with green pod yield produced by the same variety treated with 125 kg N/ha (19.32 t/ha) (Table 2) while, in case of BARI Jharshim-2, application of N @ 150 kg/ha gave the second highest green pod yield (18.05 t/ha)) that was statistically identical with 125 kg N/ha (17.98 t/ha). In 2017-18, maximum green pod yield (19.42 t/ha) was recorded from BARI Jharshim-1 in combination with 150 kg N/ha closely followed by the same variety combined with 125 kg N/ha (19.21 t/ha) and BARI Jharshim-2 with 150 kg N/ha (18.11 t/ha). In mean data, the highest green pod yield was obtained from BARI Jharshim-1 combined with 150 kg N/ha (19.48 t/ha) followed by the same variety with 125 kg N/ha (19.27 t/ha). In case of BARI Jharshim-2, no significant difference was observed between 150 and 125 kg N/ha with regard to green pod yield per hectare. Higher growth *viz*. TDM, higher number of green pods/plant and weight of green pods/plant might influence to producing the higher green pod yield at higher levels of N (125 and 150 kg N/ha). Both the varieties in both years and in mean data, gave the lowest green pod yield when no N was applied. These results are in agreement with Singh (2000) and Srinivas and Naik (1990) who recorded the maximum pod yield of French bean at 125 kg N/ha and 160 kg N/ha, respectively; the latter was identical with 120 kg N/ha. Siddiqui (2010) reported that BARI Jharsheem-1 gave the highest green pod yield of 16.38 t/ha at 150 kg N/ha). Rahman *et al.* (2018) also reported that BARI Jharshim-2 (22.7 t/ha) gave higher yield than BARI Jharshim-1(16.67 t/ha), when N @ 120 kg/ha was applied. Shahid *et al*. (2015) obtained the highest yield of pod from the application of 120 kg N/ha in French bean. Abede *et al*. (2019) reported that the highest pod yield was recorded from 100-120 kg N/ha in French bean.

Table 2. Yield attributes and pod yield of French bean as influenced by varieties and nitrogen fertilization

Treatment	Pods / plant (no.)			Weight of green pods/plant (g)			Green pod yield (t/ha)		
	Y_1	Y_2	Mean	Y_1	Y_2	Mean	Y_1	Y_2	Mean
$V_1 \times N_0$	10.40	10.17	10.28	43.38	42.70	43.04	5.78	5.74	5.76
$V_1 \times N_1$	19.28	18.87	19.07	90.93	89.40	90.17	12.09	12.01	12.05
$V_1 \times N_2$	25.04	24.56	24.80	119.70	117.70	118.70	15.80	15.70	15.75
$V_1 \times N_3$	28.68	28.08	28.38	147.10	144.60	145.90	19.32	19.21	19.27
$V_1 \times N_4$	30.01	29.40a	29.70	148.50	145.90	147.20	19.53	19.42	19.48
$V_2 \times N_0$	10.44	10.82	10.63	33.24	33.12	33.18	4.29	4.31	4.30
$V_2 \times N_1$	17.24	17.87	17.55	89.65	89.24	89.45	11.57	11.60	11.58
$V_2 \times N_2$	21.76	22.56	22.16	109.50	109.20	109.40	14.17	14.22	14.19
$V_2 \times N_3$	28.85	29.91	29.38	139.30	138.90	139.10	17.98	18.04	18.01
$V_2 \times N_4$	29.94	31.09	30.49	140.00	139.50	139.72	18.05	18.11a	18.08
LSD (0.05)	1.17	1.71	1.34	5.64	5.37	5.30	1.13	1.31	1.22

V_1=BARI Jhar shim-1, V_2 = BARI Jharshim-2; N_0 = 0 kg N/ha, N_1=75 kg/ha,N_2 = 100 kg/ha, N_3= 125 kg/ha and N_4 = 150 kg/ha: Y_1 =,2016-17, Y_2 = 2017-18.

Table 3. Effect of variety and nitrogen level on pod quality of French bean (pooled of 2016- 17 and 2017-18)

Treatment	Protein (%)	Vitamin C (mg/100g)	Vitamin A (I.U.)	TSS (%)	Calcium (mg/100g)
$V_1 \times N_0$	1.54	14.31	528.2	5.86	30.5
$V_1 \times N_1$	1.59	14.52	532.4	5.88	31.1
$V_1 \times N_2$	1.60	14.89	539.7	5.92	33.2
$V_1 \times N_3$	1.79	15.14	547.5	6.00	37.4
$V_1 \times N_4$	1.80	15.35	550.9	6.00	38.3
$V_2 \times N_0$	1.53	14.34	527.5	5.88	30.6
$V_2 \times N_1$	1.58	14.51	530.4	5.89	30.9
$V_2 \times N_2$	1.60	14.92	540.1	5.91	34.1
$V_2 \times N_3$	1.78	15.10	549.1	6.00	37.7
$V_2 \times N_4$	1.82	15.36	551.2	6.00	38.2
LSD (0.05)	0.08	0.24	7.12	0.07	2.01

V_1=BARI Jharshim-1, V_2 = BARI Jharshim-2; N_0 = 0 kg N/ha, N_1=75 kg/ha,N_2 = 100 kg/ha, N_3= 125 kg/ha and N_4 = 150 kg/ha.

Quality attributes of pod

The variety and nitrogen dose in combination showed significant effect on quality attributes of pod (Table 3). Maximum protein content was observed in $V_2 \times N_4$ combination (1.82%) closely followed by $V_1 \times N_4$, $V_1 \times N_3$ and $V_2 \times N_3$ combinations. Vitamin-C was recorded maximum (15.36 mg/100 g) in $V_2 \times N_4$ closely followed by $V_1 \times N_3$ combination. Similar trend was also observed in case of vitamin A content. The $V_2 \times N_4$ combination gave the highest vitamin-A

content (551.21 I.U.), which was identical with $V_1 \times N_4$, $V_1 \times N_3$ and $V_2 \times N_3$ combinations. The lowest values of protein, vitamin-C, vitamin-A, TSS and Ca were recorded in $V_1 \times N_0$ and $V_2 \times N_0$ combinations.

Conclusion

The combination of French bean var. BARI Jharshim-1 and 150 kg N/ha produced maximum green pod yield (19.48 t/ha) which was identical with the combination of 125 kg N/ha with the same variety (19.27 t/ha). The variety BARI Jharshim-2 in combination with both 125 and 150 kg N/ha gave reasonable pod yield (18.01-18.08 t/ha). Pods of BARI Jharshim-2 contained higher amount of protein than BARI Jharshim-1 though other quality attributes of pods were same for each variety. Therefore, French bean var. BARI Jharshim-1 and 2, and nitrogen @ 125-150 kg/ha with other nutrients might be recommended for French bean cultivation.

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